JURNAL ILMIAH TEKNIK INDUSTRI
ISSN: 1412-6869 (Print), ISSN: 2460-4038 (Online)
Journal homepage: http://journals.ums.ac.id/index.php/jiti/index
doi: 10.23917/jiti.v23i1.4461

Production Floor Relayout to Optimize Material Handling Distance at PT. Sidoagung Farm Magelang

Moehamad Aman[1a]◆, Rosna Dewi Larasati[1b], Tuessi Ari Purnomo[1c]

Abstract. *PT. Sidoagung Farm Magelang is one of the industries engaged in animal feed. The problem in this company is the arrangement of machines per department on an irregular production line, so that the interrelated production processes are quite far apart. Machines that have the same function and are far apart include: corn grinding machine and soybean grinder 9 meters apart, mixer machine 1, mixer machine 2 and mixer machine 3 each 1.5 meters and 18 meters apart, packaging 1 and packaging 2 is 27.4 meters away. In order to overcome these problems, this study proposes a method to optimize distance using a Group Technology approach, namely the Rank Order Clustering (ROC) method for grouping machines with similar parts. The design of the proposed layout uses Blockplan Software and the calculation of the distance with the rectilinear formula. The results of this study resulted in 3 grouping machines. Group 1 grinding machines are 1 meter apart, group 2 mixer machines are 1 meter apart each, group 3 packaging machines are 1.5 meters apart. The total displacement of the material handling distance using the rectilinear formula in the initial layout is 191 meters, while for the displacement of the material handling distance, the proposed layout is 117.5 meters. With the comparison of the initial and proposed layout distance is 73.5 meters so that the proposed layout optimizes the distance between machines by 62%*

Keywords: *group technology, rank order clustering, blockplan, rectilinear*

I. INTRODUCTION

The animal feed industry is one of the industries in Indonesia. The animal feed industry is increasing from year to year. Based on the Livestock Feed Company Movement explained that from 2015 to 2019 animal feed production has increased, where every year there is an increase in demand and production of up to 2 million tons (GPMT, n.d., 2019). Currently, there are 111 animal feed factories in Indonesia with a production capacity of 26.73 million tons. Charoen Pokphand Indonesia leads with the largest production, followed by Japfa Comfeed Indonesia, Cheil Jedang Feed Indonesia, Malindo Feedmill, New Hope Indonesia, Wonokoyo Jaya Corporindo, Gold Coin Indonesia, Central Proteina prima and other companies.

PT. Sidoagung Farm Magelang is located on Jl. Mayjend Bambang Soegeng No.118 Magelang, Magelang is one of the industries engaged in animal feed. This company uses the Make By Order strategy to meet consumer demand so that the total production cannot be averaged the same. PT. Sidoagung in a day can produce 70 tons/1,400 sacks of animal feed, the capacity of the machine used is able to accommodate raw materials, which is 2.5 tons - 60 tons in one processing. The area of the production section is 35 m x 10 m. The problem in this company is that the arrangement of machines per department on the production line is irregular so that the interrelated production processes are quite far apart. Material transfer is carried out using pick up cars and trolleys. The material handling distance is far apart resulting in inefficient trolley movement used by workers, the entry of pick-up cars delivering raw materials into the production department disrupts the movement of trolley users, resulting in delays to get to the next station. The types of facility layout commonly used are process layout, product layout, fixed position layout and group technology layout. PT. Sidoagung Magelang has not yet implemented

[1] Department of Industrial Engineering, Facullty of Engineering, Universitas Muhammadiyah Magelang, Jl. Mayjend. Bambang Soegeng, Magelang 56172

[a] email: aman@unimma.ac.id
[b] email: rosnadewilrst@gmail.com
[c] email: tuessi@gmail.com
◆ corresponding author

Submited: 29-11-2023 Revised: 06-06-2024
Accepted: 15-06-2024

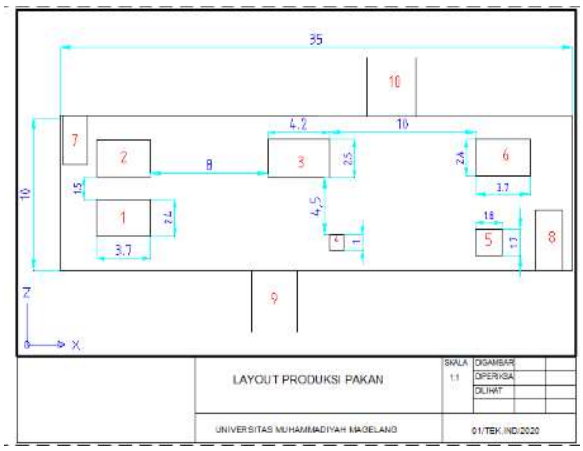
the four layouts. One of the four layouts is very much needed for the company, namely the technology layout group, because the implementation of this layout places the engine layout in the same line.

Based on the problems with the previous layout, a research will be conducted that aims to optimize the distance of material handling during the production process with a new production floor layout design, through grouping the same machine to optimize the distance of material movement on the production floor at PT. Sidoagung Farm Magelang Magelang.

II. RESEARCH METHOD

The method used in this study begins with analyzing the feed production section, calculating with group technology, selecting the best group method, designing a new layout, comparing the distance between the initial and proposed material handling layouts, and ending with the best layout recommendations.

1. Analysis of the feed production section. At this stage, the initial layout of the feed production floor department is carried out to determine the layout of the machine, data on the area and distance between production machines and the linkage of the activities of the production process flow in the department. The initial layout of the production department is shown in Figure 1. Analysis of the feed production process flow, the feed production process flow from raw materials into the production section is then processed to become finished feed products. Making Activity Relations Chart (ARC), entering the name of the machine in the production section of PT. Sidoagung Farm Magelang. The purpose of the Activity Relations Chart (ARC) is to determine the relationship between the degree of linkage that absolutely needs to be brought closer in order to minimize the distance between interrelated machines. From To Chart distance measurement, measuring the distance from one machine to another in the layout of the animal feed production section.



Description: (1)Mixer Machine 1, (2)Mixer Machine 2, (3)Soybean Grinding Machine, (4)Scale, (5) Corn.Grinding Machine, (6)Mixer Machine 3, (7)Packaging Room 1, (8)Packaging Room 2, (9) Production room entrance, (10)Production room exit

Figure 1. Existing Layout Production Department (PT. Sidoagung Farm Magelang)

2. Group Technology. After getting the results of the analysis in the required production section, the next step is to group similar machines by starting the Group Technology calculation which will be explained in the ROC, DCA, Grouping Efficiency and efficacy calculations section.
3. Rank Order Clustering (ROC) Calculation. Calculation of Rank Order Clustering (ROC) which is useful for grouping machines with similar parts. Here are the steps for calculating calculations Rank Order Clustering (ROC):
   a. Making Table of insident matrix. Making this table is done by determining the type of machine and the order of the related raw materials. Each row represents the number of machines and each column represents the order quantity of raw materials.

Table 2. Insident matrix

	P1	P2	P3	P4	P5	P6	P7	Total
M1	1		1		1	1		
M2		1		1	1			
M3	1		1			1		
M4	1	1			1			
M5			1	1		1	1	
Total								

b. Calculation of Weight for machine and part. After grouping machines and parts in the incident matrix based on the same type, then the equivalent weighting calculation for each row is carried out based on the binary system and determines the ranking order.
c. Grouping Machine and Part. After there is no change in the arrangement of rows and columns, the iteration process stops. The results of the grouping can be chosen freely based on the relationship between the machine process and the part.

4. Calculation of Direct Clustering Algorithm (DCA). The difference between DCA and ROC is that the sorting is done directly without weights, using only the left-most positive cells rule. Following are the steps for calculating the Direct Clustering Algortim (DCA):
   a. Making Table of insident matrix. The Incident Matrix table was created to determine the type of machine and the order of raw materials related to entering binary numbers (1 or 0).
   b. Calculation of the number of part relationships with the machine in rows and columns
   c. The calculation is done by counting the number of part relationships with the machine by adding binary values for each row and column.
   d. Sorting with left-most cells. Sorting with left-most cells which is done directly without using weights based on the value of the largest to the smallest number.
   e. Groupng machine and parts in table of insident matrix. At this stage is the grouping of machines and parts when it gets a better formation then the iteration process stops.
5. Choosing the best method. The selection of the best method which is seen from the results of both will be recalculated with the calculation of grouping efficiency and grouping efficacy. Calculation of grouping efficiency and efficacy to evaluate the end of the Rank Order Clustering (ROC) and Direct Clustering Algorithm (DCA) methods
6. Designing New Layout using software blocplan. Making a new layout after getting all the data and work using the blockplan software.
7. Coparing distance of material handling existing layout and proposed. After the new layout has been designed through the blockplan software, the material handling distance is calculated for the initial layout and proposal. Calculation of material handling distance with rectilinear formula

III. Result and Discussion

Analysis of the feed production section

Departement of Feed production Floor. PT. Sidoagung Farm Magelang Magelang has several departments, one of which is the production floor department which has a building area of 35 m x 10 m. Figure 1 shows the feed production floor department of PT. Sidoagung Farm Magelang.

Feed production process flow data. The flow

Figure 2. Feed production floor department (PT. Sidoagung Farm Magelang)

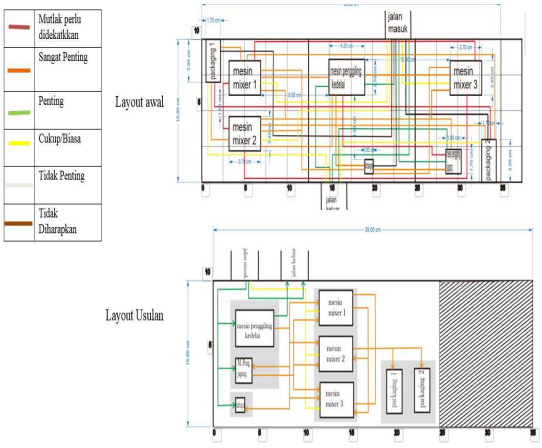


Figure 3. Activity Relations Chart (PT. Sidoagung Farm Magelang)

Table 3. From To Chart

From/To	Distance (m)									
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
Entrance (A)		1.0	2.0	9.0	6.0	6.0	2.0	6.5	2.5	7.0
Corn Grinding Machine (B)			9.0	8.0	22.2	22.2	3.5	22.7	1.0	11.5
Soybean Grinding Machine (C)				4.5	8.0	8.0	10.0	8.5	10.5	5.0
Scale (D)					8.0	8.0	10.0	8.5	10.5	5.0
Mixer Machine 1 (E)						1.5	10.0	2.5	18.5	2.0
Mixer Machine 2 (F)							18.0	2.5	18.5	2.5
Mixer Machine 3 (G)								19.5	3.3	12.0
Packaging 1 (H)									27.4	18.0
Packaging 2 (I)										13.0
Exit (J)										

Table 4. Code of machine and part

Machine	Dimension (m)	Quantity	Code of Machine	Part	Code of Part
Corn Grinding Machine (B)	1.8 x 1.7	1	M1	Corn bean	P1
Soybean Grinding Machine (C)	4.2 x 2.5	1	M2	Soy bean	P2
Scale (D)	1.0 x 1.0	1	M3	Bekatul	P3
Mixer Machine 1 (E)	3.7 x 2.4	1	M4	Meat Bone Meal (MBM)	P4
Mixer Machine 2 (F)	3.7 x 2.4	1	M5	Calcium powder	P5
Mixer Machine 3 (G)	3.7 x 2.4	1	M6	Polar	P6
Packaging 1 (H)	0.3 x 0.2 x 0.2	1	M7	Grit	P7
Packaging 2 (I)	0.3 x 0.2 x 0.2	1	M8	Vegetable oil	P8
				Poultry	P9

of the feed production process begins with taking corn and soybeans from the warehouse, then the corn and soybean milling process, weighing, mixing and packaging processes

Proximity relationship data between departments initial layout. This data is in the form of images to determine the close relationship between machine facilities in the production department at PT. Sidoagung Farm Magelang. From the Activity Relations Chart image in the initial layout, it can be seen that there is a line connecting the red machines which means "absolutely needs to be brought closer" such as a soybean grinder with a corn grinder, mixer 1, mixer 2 and mixer 3. related, the use of space, the work function of the same machine. Here is a picture of the Activity Relations Chart.

Distance measurement data between machines (From To Chart). This data is to determine the size of the distance between one machine to another in the feed production section in the initial layout, it can be seen in Table 3.

Machines that have the same function and are far apart include: corn grinding machine and soybean grinder 9 meters away, mixer machine 1, mixer machine 2 and mixer machine 3 each 1.5 meters and 18 meters apart, packaging 1 and packaging 2 is 27.4 meters.

Group Technology

Below is a table of machine data along with codes, existing quantities and parts along with codes in the feed production department that will be entered into the incident matrix table to calculate Rank Order Clustering and Direct Clustering Algorithm, which can be seen in Table 4.

Calculation of Rank Order Clustering (ROC)

Table insident matrix. The incident matrix table is arranged by placing the machine code vertically and part code horizontally by entering binary weights (0 or 1), which can be seen in Table 5.

Calculation of machine and part weight. The calculation of machine and part weights is carried

Table 5. Insident matrix

No	Machine	Part								
		P1	P2	P3	P4	P5	P6	P7	P8	P9
1	M1	1	0	0	0	0	0	0	0	1
2	M2	0	1	0	0	0	0	0	0	1
3	M3	1	1	0	0	0	0	0	0	1
4	M4	1	1	1	1	1	1	1	1	1
5	M5	1	1	1	1	1	1	1	1	1
6	M6	1	1	1	1	1	1	1	1	1
7	M7	0	0	0	0	0	0	0	0	1
8	M8	0	0	0	0	0	0	0	0	1

Table 6. Calculation of machine and part weight

No		Machine	Part									Weighted	Ranked
			2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0		
			P1	P2	P9	P3	P4	P5	P6	P7	P8		
1	2^7	M4	1	1	1	1	1	1	1	1	1	511	1
2	2^6	M5	1	1	1	1	1	1	1	1	1	511	2
3	2^5	M6	1	1	1	1	1	1	1	1	1	511	3
4	2^4	M3	1	1	0	0	0	0	0	0	0	384	4
5	2^3	M1	1	0	1	0	0	0	0	0	0	320	5
6	2^2	M2	0	1	1	0	0	0	0	0	0	192	6
7	2^1	M7	0	0	1	0	0	0	0	0	0	64	7
8	2^0	M8	0	0	1	0	0	0	0	0	0	64	8
		Weighted	284	244	239	224	224	224	224	224	224		
		Ranked	1	2	3		5	6	7	8	9		

Table 7. Result of Grouping Rank Order Clustering

No		Machine	Part								
			2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
			P1	P2	P9	P3	P4	P5	P6	P7	P8
1	2^7	M4	1	1	1	1	1	1	1	1	1
2	2^6	M5	1	1	1	1	1	1	1	1	1
3	2^5	M6	1	1	1	1	1	1	1	1	1
4	2^4	M3	1	1	0	0	0	0	0	0	0
5	2^3	M1	1	0	1	0	0	0	0	0	0
6	2^2	M2	0	1	1	0	0	0	0	0	0
7	2^1	M7	0	0	1	0	0	0	0	0	0
8	2^0	M8	0	0	1	0	0	0	0	0	0

out on rows and columns in the incident matrix table by multiplying by binary weights 28 to 20 to find out the weights and then ranked from largest to smallest, can be seen in Table 6.

Grouping machine and part in insident matrix. The results of the grouping can be seen based on the relationship between the machine process and the part, which can be seen in Table 7.

Calculation Direct Clustering Algortihm (DCA)

Table insident matrix. The Incident Matrix table was created to determine the type of machine and the order of raw materials related to entering binary numbers (1 or 0), which can be seen in Table 8.

Calculation of the number of part relationships with the machine in rows and columns. Counting the number of part relationships with the machine by adding binary values for each row and column, can be seen in Table 9.

Sorting with left-most cells. Left most cells is sorting that is done directly without using weights by sorting the values of the largest to the smallest number in the machine row and part column, which can be seen in Table 10.

Grouping machine and part in table of Incident Matrix. At this stage, the grouping of machines and parts is done when they have got a good formation, as follows, it can be seen in Table 11.

Table 8. Table insident matrix

No	Machine	Part								
		P1	P2	P3	P4	P5	P6	P7	P8	P9
1	M1	1	0	0	0	0	0	0	0	1
2	M2	0	1	0	0	0	0	0	0	1
3	M3	1	1	0	0	0	0	0	0	0
4	M4	1	1	1	1	1	1	1	1	1
5	M5	1	1	1	1	1	1	1	1	1
6	M6	1	1	1	1	1	1	1	1	1
7	M7	0	0	0	0	0	0	0	0	1
8	M8	0	0	0	0	0	0	0	0	1

Table 9. Calculation of the number of part and machine in rows and columns

No	Machine	Part									Total
		P1	P2	P3	P4	P5	P6	P7	P8	P9	
1	M1	1	0	0	0	0	0	0	0	1	2
2	M2	0	1	0	0	0	0	0	0	1	2
3	M3	1	1	0	0	0	0	0	0	0	2
4	M4	1	1	1	1	1	1	1	1	1	9
5	M5	1	1	1	1	1	1	1	1	1	9
6	M6	1	1	1	1	1	1	1	1	1	9
7	M7	0	0	0	0	0	0	0	0	1	1
8	M8	0	0	0	0	0	0	0	0	1	1
	Total	5	5	3	3	3	3	3	3	7	

Table 10. Sorting with left-most cells

No	Machine	Part									
		P9	P1	P2	P3	P4	P5	P6	P7	P8	Total
1	M4	1	1	1	1	1	1	1	1	1	9
2	M5	1	1	1	1	1	1	1	1	1	9
3	M6	1	1	1	1	1	1	1	1	1	9
4	M1	1	1	0	0	0	0	0	0	0	2
5	M2	1	0	1	0	0	0	0	0	0	2
6	M3	0	1	1	0	0	0	0	0	0	2
7	M7	1	0	0	0	0	0	0	0	0	1
8	M8	1	0	0	0	0	0	0	0	0	1
	Total	7	5	5	3	3	3	3	3	3	

Table 11. Grouping machine and parts

No	Machine	Part								
		P9	P1	P2	P3	P4	P5	P6	P7	P8
1	M4	1	1	1	1	1	1	1	1	1
2	M5	1	1	1	1	1	1	1	1	1
3	M6	1	1	1	1	1	1	1	1	1
4	M1	1	1	0	0	0	0	0	0	0
5	M2	1	0	1	0	0	0	0	0	0
6	M3	0	1	1	0	0	0	0	0	0
7	M7	1	0	0	0	0	0	0	0	0
8	M8	1	0	0	0	0	0	0	0	0

Choosing the best method

After calculating with Rank Order Clustering (ROC) and Direct Clustering Algorithm (DCA), the next step is choosing the best method by calculating Grouping Efficiency and Grouping Efficacy. From the calculation of the Rank Order Clustering method, the grouping efficiency and grouping efficacy values are greater, namely 1.57 and 0.96. Thus the best machine and part grouping method uses Rank Order Clustering (ROC).

Designing New Layout using software Blocplan. Making layouts using blockplan software. The selected results are the highest adj-score and R-dist-score values that are close to 1. It was found that the one with the highest adj-score value was in iteration 2 with a value of 0.84.

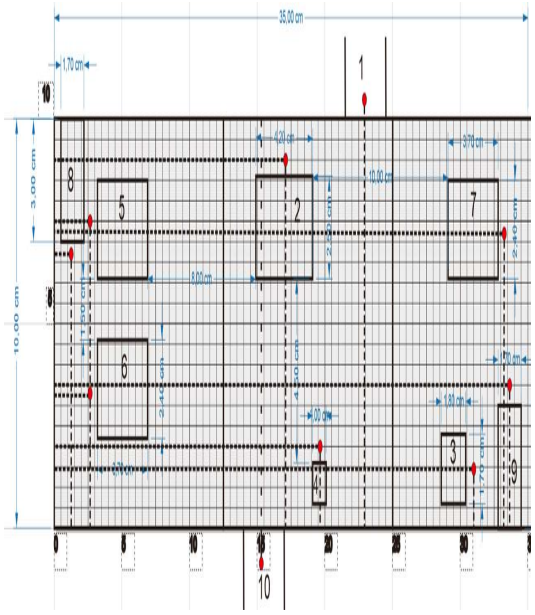


Figure 4. Existing Layout

Table 12. Coordinate X dan Y

No	Machine	X (m)	Y (m)
1	Entrance (A)	23.0	10.0
2	Corn Grinding Machine (B)	17.5	9.25
3	Soybean Grinding Machine (C)	31.25	1.75
4	Scale (D)	20.0	2.25
5	Mixer Machine 1 (E)	3.0	3.5
6	Mixer Machine 2 (F)	7.5	7.75
7	Mixer Machine 3 (G)	33.5	8.0
8	Packaging 1 (H)	1.5	7.0
9	Packaging 2 (I)	34.0	3.75
10	Exit (J)	15.0	0.0

Comparison of the initial and proposed layout material handling distance. The calculated distance is the distance of the initial material handling layout and the proposed layout using the rectilinear formula. The following is an image of the initial layout for calculating the rectilinear formula.

Based on the initial layout image above, the determination of the coordinates refers to the position of the employee when carrying out activities at the work station. The coordinates in the figure are indicated by red dots. Description of the location of the work station and the coordinates in the initial layout of the image above can be seen in Table 12.

From the results of the determination of the coordinates, it is then calculated using a rectilinear formula with the order of the flow of the production process. The results of the calculation of the distance according to the order of the flow of the production process are shown in Table 13. Figure 5 is an image of the proposed layout for calculating the rectilinear formula.

Based on Figure 5, it is the result of the design of the blockplan software. Furthermore, the proposed layout is also calculated with the rectilinear distance formula for determining the coordinates referring to the position of the employee when carrying out activities at the work station. The coordinates in the figure are indicated by red dots. Information on the location of the machine station and the coordinates in the proposed layout of the image above can be seen in Table 14. Furthermore, the calculation results

Table 13. The result of calculating the distance with formulae rectilinear

No	From -- To	Distance (m)
1	Entrance -- Soybean Grinding Machine	6.25
2	Entrance -- Corn Grinding Machine	16.5
3	Entrance -- Exit	17.5
4	Exit -- Soybean Grinding Machine	11.25
5	Exit -- Corn Grinding Machine	17.5
6	Soybean Grinding Machine -- Scale	9.5
7	Corn Grinding Machine -- Scale	11.75
8	Scale -- Mixer Machine 1	18.25
9	Scale -- Mixer Machine 2	19.0
10	Scale -- Mixer Machine 3	19.25
11	Mixer Machine 1 -- Packaging 1	5.0
12	Mixer Machine 2 -- Packaging 1	6.75
13	Mixer Machine 3 -- Packaging 2	4.75
	Total distance	191

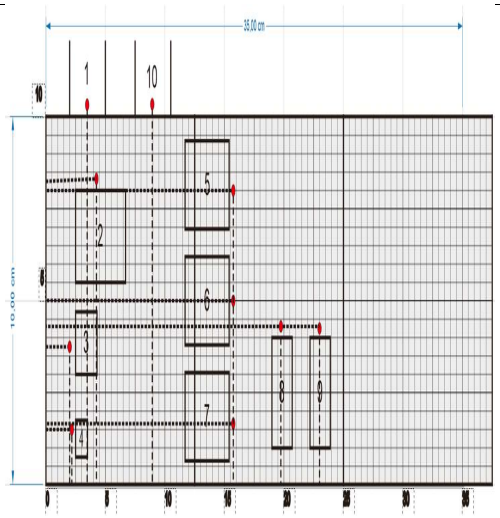


Figure 5. Proposed Layout

Table 14. Coordinate X dan Y

No	Machine	X (m)	Y (m)
1	Entrance	3.5	10.0
2	Soybean Grinding Machine	4.5	9.0
3	Corn Grinding Machine	2.0	4.0
4	Scale	2.5	1.75
5	Mixer Machine 1	15.0	8.0
6	Mixer Machine 2	15.0	5.0
7	Mixer Machine 3	15.0	2.0
8	Packaging 1	19.0	4.5
9	Packaging 2	22.0	4.5
10	Exit	10.0	0.0

Table 15. The result of calculating the distance with the rectilinear

No	From -- To	Distance (m)
1	Entrance -- Soybean Grinding Machine	2.0
2	Entrance -- Corn Grinding Machine	6.5
3	Entrance -- Exit	7.5
4	Soybean Grinding Machine -- Exit	5.5
5	Corn Grinding Machine -- Exit	13.0
6	Soybean Grinding Machine -- Scale	9.25
7	Corn Grinding Machine -- Scale	2.0
8	Scale -- Mixer Machine 1	18.75
9	Scale -- Mixer Machine 2	15.75
10	Scale -- Mixer Machine 3	12.75
11	Mixer Machine 1 -- Packaging 2	10.5
12	Mixer Machine 2 -- Packaging 1	4.5
13	Mixer Machine 3 -- Packaging 1	6.5
14	Packaging 1 -- Packaging 2	3.0
	Total distance	117.5

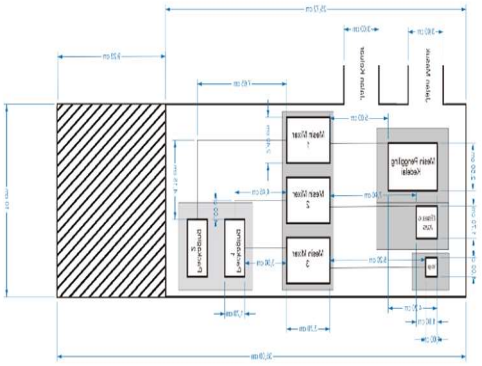


Figure 6. Result Proposed Layout using software blocplan

are shown in Table 15.

From the results of the material handling distance, the two layouts that have been calculated using the rectilinear formula for the initial layout produce a total distance of 191 meters, while for the proposed blocplan layout the total distance is 117.5 meters. The comparison between the initial layout and the proposed distance is 73 meters. The following is the final result of the proposed layout drawing.

The results of this study resulted in 3 grouping machines. Group 1 grinding machines are 1 meter apart, group 2 mixer machines are each 1 meter apart, and group 3 packaging machines are 1.5 meters apart.

IV. Conclusion

The design of groups of machines on the production floor of PT. Sidoagung Farm Magelang into the optimal incident matrix table is the group technology approach, namely the Rank Order Clustering method which produces 3 groups of machines consisting of grinding machines, mixing machines, inner sack sewing machines. packaging room and 9 variations of parts. The grouping of machines is done based on the calculation of the Rank Order Clustering Method, the grouping of machines and parts has a related process. The Rank Order Clustering method has a grouping efficiency calculation result of 1.57 and a grouping efficacy of 0.96.

The research resulted in the proposed layout of the production floor facility that was able to optimize the distance for material handling PT. Sidoagung Farm Magelang by using the Group Technology approach and Blocplan software along with calculating the distance using the rectilinear formula. The total displacement of the material handling distance in the initial layout is 191 meters, while for the displacement of the material handling distance, the proposed layout is 117.5 meters. With a comparison of the initial and proposed layout distance is 73.5 meters.

V. References

Atik Antika, 2018, dan, P., Di, K., & Xyz, P. T. (2018). Alternatif Perbaikan Menggunakan Pendekatan Group Technology dan Computerized Relationship.

Attamiimi, A., & Nindri, G. A. (2015). Alternatif Perbaikan Tata Letak Lantai Produksi Pt. Japfa Comfeed Indonesia Dengan Metode Systematic Layout Planning (Slp). Sinergi, 19(3), 217.

Fajarika, D., Gusvita, R., & Sofriani, N. (2019). Perancangan Tata Letak Laboratium Pakan Dengan Metode Computerized Relationship Layout Layout

Planning di Industri Penggemukan Sapi. 3(August), 68–77.

Febianti, E. (n.d.). Relayout Fasilitas Produksi Dengan Menggunakan Algoritma Blocplan. 125–133.

Harma, B., & Sudra, H. I. (2020). Analisa Perbaikan Tata Letak Penempatan Bahan Baku. 10(2), 15–22.

Ibnu Abdillah, (2019), *Usulan Perbaikan Tata Letak Fasilitas Dengan Menggunakan Metode Blocplan dan Corelap Untuk Meminimumkan Jarak Material handling* (Studi Kasus Divisi Produksi Suku Cadang PT. Slamet Sumbing Semarang). 87–115.

Matthew P. Stephens, F. E. M. (2013). Manufacturing Facilities Design & Material handling.

Wuryanto, N.A., (2017), *Perancangan Group Technology Layout Untuk Mengurangi Jarak Material Handling Pada Lantai Produksi Perusahaan Manufaktur Lantai Kayu*. Sarjana thesis, Universitas Brawijaya

Rengganis, E., (2015), Perbandingan Optimasi Re-layout Penempatan Fasilitas Produksi Dengan Menggunakan Craft Guna Meminimalkan Biaya Material handling. *Jurnal Angkasa*, 181–198.

Rodliyah, A., Choiri, M., & Himawan, R. (2014). Perancangan Tata Letak Lantai Produksi Dengan Pendekatan Group Technology Untuk Mengurangi Jarak Material Handling (Studi Kasus di PT Indonesian Marine Corp. Ltd Divisi Boiler Singosari-Malang). *Jurnal Rekayasa dan Manajemen Sistem Industri,* 2(3), p470-481

http://jrmsi.studentjournal.ub.ac.id/index.php/jrmsi/article/view/99

Ula, G. A. N. (2014). Perancangan Ulang Tata Letak Unit Industrial Gas Turbine PT. GMF AEROASIA